

Multipurpose Pressure Vessel Scanner and Photon Doppler Velocimetry



Figure 1: Multipurpose Pressure Vessel Scanner with a developmental tank installed running a scan with a spare eddy current probe.

Critical flight hardware typically undergoes a series of nondestructive evaluation methods to screen for defects before it is integrated into the flight system. Conventionally, pressure vessels have been inspected for flaws using a technique known as fluorescent dye penetrant, which is biased to inspector interpretation. An alternate method known as eddy current is automated and can detect small cracks better than dye penetrant. A new multipurpose pressure vessel scanner has been developed to perform internal and external eddy current scanning, laser profilometry, and thickness mapping on pressure vessels. Before this system can be implemented throughout industry, a probability of detection (POD) study needs to be performed to validate the system's eddy current crack/flaw capabilities.

The POD sample set will consist of 6 flight-like metal pressure vessel liners with defects of known size. Preparation

for the POD includes sample set fabrication, system operation, procedure development, and eddy current settings optimization. For this, collaborating with subject matter experts was required. This technical paper details the preparation activities leading up to the POD study currently scheduled for winter 2015/2016. Once validated, this system will be a proven innovation for increasing the safety and reliability of necessary flight hardware.

Additionally, testing of frangible joint requires Photon Doppler Velocimetry (PDV) and Digital Image Correlation instrumentation. There is often noise associated with PDV data, which necessitates a frequency modulation (FM) signal-to-noise pre-test. Generally, FM radio works by varying the carrier frequency and mixing it with a fixed frequency source, creating a beat frequency which is represented by audio frequency that can be heard between about 20 to 20,000 Hz. Similarly, PDV reflects a shifted frequency (a phenomenon known as the Doppler Effect) from a moving source and mixes it with a fixed source frequency, which results in a beat frequency. However, for PDV, discerning the signal from the noise is difficult without a moving source to induce the modulation. A rotating wheel is currently being used as the moving source but its configuration is impractical and has cumbersome placement inside the current frangible joint test cell. As a way to combat this problem and verify a satisfactory signal-to-noise ratio, a reflective moving crystal piezo will be used to modulate a beat frequency, and an absorptive target will be used to block the signal in order to determine any back reflection coming from the probe and discern the true signal-to-noise ratio. The piezo will be mounted and inserted onto the test table on an extendable telescopic antenna grounded by a magnetic base in the test zone. This piezo configuration will be more compatible within the test zone and allow for easy removal of the disk following acceptable signal verification and prior to frangible joint tests.



Figure 2: Preliminary CAD drawing with the telescopic configuration.